Nutrition-related research at USDA's Eastern Regional Research Center

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In the thirty-five years of its existence, the Eastern Regional Research Center in Philadelphia has been concerned with research on nutrition. At one time, in fact, it was known as the Eastern Marketing and Nutrition Research Division of USDA's Agricultural Research Service.

Most of the workers at the Center are chemists, chemical engineers, microbiologists, and food scientists and technologists, Since so much of their research is devoted to basic foods—milk, meat, fruits, and vegetables—it bears significantly on nutrition.

More efficient and economical processing, the basic aim of the Center's research on these commodities, obviously relates not only to savings in time, materials, and labor, but to protection of the environment and preservation of nutritional value in processed foods.

Research on whey

One agricultural byproduct, the utilization of which involves both of these latter considerations, is whey, the watery substance left from the manufacture of cheese. For a half century, USDA scientists have been urging cheesemakers to take advantage of the valuable proteins, vitamins, minerals, and sugar in the whey which has often been disposed of as waste. In the past decade, legislation has been passed forbidding the disposal of whey into streams without costly treatment to reduce its biologic oxygen demand. As a result, more whey is now being utilized in both foods and animal feeds. Actually, whey is an excellent source of nutrients. Rat studies have shown whey protein concentrate to be superior to casein in promoting growth (1). As Table 1 shows, whey protein meets or exceeds the FAO standard profile for each essential amino acid (2). Most of the important vitamins in nonfat dry milk are also present in equivalent or greater amounts in dried whey, and whey compares well with milk in its content of iron, magnesium, potassium, and sodium (3-6) (Table 2). Thus, if 100 gm. nonfat dry milk (about two glasses after reconstitution) per day provide most of the vitamins and minerals recognized as required for children, whey is a promising base for a nutritionally adequate milk substitute.

WHEY-SOY DRINK MIX. The nutritional advantages of whey were exploited in the development of a whey-soy drink mix now being distributed through relief agencies throughout the world to infants and preschool children under the Food-for-Peace program of the Agency for International Development (7). The product is based on a whey beverage, first made in Washington, D.C., about ten years ago by scientists in what is now the Dairy Laboratory of the Eastern Regional Research Center. Later, the beverage was modified by these and other researchers in a cooperative program that involved food technologists and nutritionists inside and outside of government to make a product that is at least equivalent in nutritional value to nonfat dry milk. Specifications were prepared at the Center after world-wide testing established its acceptability.

The whey-soy drink consists of 42 per cent sweet whey solids, 37 per cent full-fat soy flour, 12 per cent soybean oil, and 9 per cent corn sirup solids. It may be fortified with 1 per cent additional vitamins and minerals, if desired. The combination of animal and vegetable proteins in this mixture may well presage a whole new family of food products for consumption at home, as well as abroad.

Table 1: Essential amino acid content of whey protein and casein, as compared with FAO standard* (2)

amino acid	*whey protein*	*casein*	FAO *standard*
	← *gm./100 gm. protein* →		
methionine	4.3	3.4	4.2
leucine	15.5	16.4	9.0
lysine	8.2	8.2	4.2
phenylalanine	4.0	5.5	2.8
threonine	5.5	4.5	2.8
valine	5.5	7.3	4.2
tyrosine	3.7	6.2	2.8
tryptophan	2.5	1.4	1.4

*Nutritional standard profile recognized by the Food and Agriculture Organization of the United Nations.

WHEY PROTEINS. The proteins of whey show special promise for the nutritional fortification of foods. Scientists of the USDA have developed a method of treating cottage cheese whey that results in a powder consisting of 80 to 90 per cent protein (8). Use of this powder in the manufacture of such staple foods as bread (9) and pasta (10) adds significantly to their nutritional value, but does not require substantial processing changes or lower the products' acceptability.

Similar whey protein fractions can also be added

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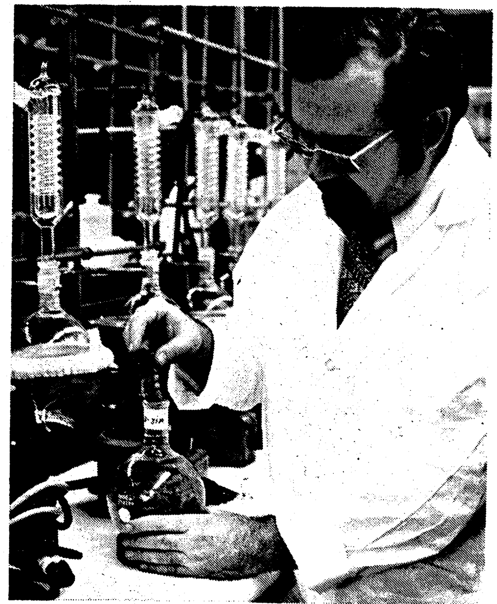
Table 2: Vitamin and mineral content of dried whey as compared to nonfat dry milk

nutrient	*dried whey*	*nonfat dry milk*	*approximate requirement for 10-kg. child*	*reference*
	←*mg./100 gm.*	→	*mg./day*	
vitamins				
thiamin	0.50	0.35	0.4	(3)*
riboflavin	2.53	1.81	0.6	(3)
niacin	0.8	0.9	6.0	(3)
vitamin B_6	—†	0.380	0.5	(4)
biotin	0.04	0.025	—	(5)
pantothenic acid	4.000	3.600	5.0	(4)
folic acid	0.09	0.06	0.1	(5)
choline	200	200	—	(5)
vitamin B_{12}	0.0020	0.0032	—	(4)
vitamin A	51‡	31‡	1,500‡	(3)
minerals				
calcium	651	1,318	600	(3)
iron	1.4	0.6	10	(3)
magnesium	130	143	100	(3)
phosphorus	594	1,024	700	(3)
potassium	—#	1,760	400	(3)
sodium	700	526	400	(3)

*Values converted from mg./lb. to mg./100 gm.
†Although reference (4) gives no value for vitamin B_6 in dried whey, it does show 0.040 mg./100 gm. for fluid whey and 0.042 mg./100 gm. for fluid skim milk.
‡International units.
#The potassium content of sweet whey protein concentrate is reported to be 1.5 per cent; that of nonfat dry milk, 1.7 per cent (6).



Bacon in a laboratory flask in an early step in its analysis for nitrosamines.

to soft drinks (11), and research done some years ago showed that whole cottage cheese whey, dried to a powder, could be used to replace some of the sugar in ice lollipops (12). Thus, these "fun" foods, which are consumed so ravenously by youngsters, can be converted into vehicles of added nutrition.

Another powder obtainable from cottage cheese whey provides a combination of protein and iron (13). It is made by treating whey with ferripolyphosphate, a mixture of a commercially available polyphosphate widely used as a water softener and the iron compound ferric chloride. Not only can this powder be added experimentally to milk and bread without affecting their acceptability, but the iron in it has also been shown to be nutritionally available. In tests with iron-depleted rats, the powder was 93 per cent as effective as ferrous sulfate in restoring hemoglobin levels.

Lactose

Although the protein is the most valuable part of whey, lactose is its most abundant component. Composing about 70 per cent of the whey solids, this not-very-sweet sugar is difficult for some people—notably non-Caucasians—to digest. Many of these people are lactose-intolerant; that is, their systems lack the amount of the enzyme, lactase, needed to hydrolyze lactose in a test dose to two simpler and digestible sugars, glucose and galactose.

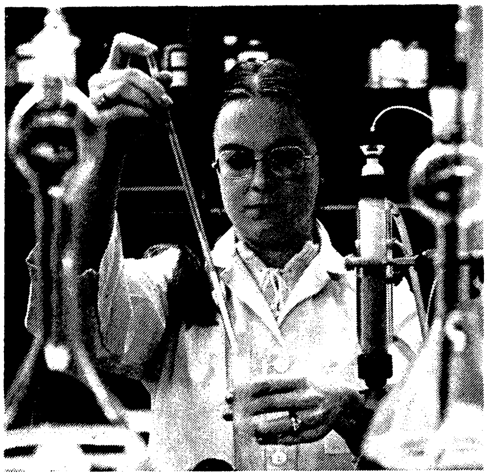
Scientists of the Eastern Regional Research Center are experimenting with the treatment of milk with lactase from microbial sources, such as from the yeast, *Saccharomyces lactis* (14). The treatment makes milk digestible for the lactose-intolerant without affecting its taste, other than to sweeten it. (Glucose and galactose are sweeter sugars than lactose.)

The treatment is largely experimental at this time, due primarily to the high cost of the lactase. But scientists at the Center are finding that lactase treatment has many other potential advantages (15). The sweeter lactase-treated milk can be used to make ice cream with less sucrose—in days of high sugar prices, an economic as well as a nutritional benefit. Preliminary work also indicates that cheese made from lactase-treated milk ripens faster. So it may be advantageous to hydrolyze lactose before the cheese is made.

Polyunsaturated milk and meat

While nutritionists debate the role of saturated fats in the diet as a contributor to atherosclerosis, USDA scientists have been investigating an idea for the natural production of milk and meat with a higher ratio of polyunsaturated-to-saturated fatty acids. In this scheme, first proposed in Australia, cattle are raised on feed containing an oil high in polyunsaturates, such as safflower oil, that is mixed with casein and coated with formaldehyde so that rumen microorganisms cannot saturate it. Fed this "protected" oil, cattle give milk with ten times, and meat with four times, the normal amount of polyunsaturated acids. The saturated acids in the milk fat and meat fat are correspondingly reduced (16).

How soon meat and milk produced this way may become commercial realities is hard to say. Of course,



Laboratory experiment in the treatment of milk with the enzyme lactase, which converts the disaccharide, lactose, into glucose and galactose.

the feeding regimen required would add to their cost. Furthermore, antioxidants may be required to suppress oxidation of the polyunsaturated fats in the storage of such products. Flavor defects arise in the milk after only a short time in the refrigerator. Polyunsaturated beef has a satisfactory flavor, but its freezer storage life is not much greater than that of pork. In addition, before the complete practicality of this proposal can be established, more animal husbandry experiments would be needed on the effect of feeding the encapsulated oils on the health and vigor of cattle.

Nitrate, nitrite, and nitrosamines

Guarding the wholesomeness and nutritional value of our food supply involves concern for potentially harmful compounds that may be present naturally or introduced in processing. Such a compound is nitrate. Nitrate is innocuous in itself, but it can be converted to nitrite, which in turn may conceivably combine with secondary amines to form nitrosamines, which are potential carcinogens (17).

Nitrate occurs naturally in beets and spinach. It can be converted to nitrite if these vegetables are not properly stored, as has been known for some years. Research at the USDA Center in Philadelphia detected significant amounts of nitrite in home-prepared purées of beets and spinach that had been subjected to considerable storage abuse; however, all tests for nitrosamines in these nitrite-containing samples were negative (18).

Trace amounts of nitrosamines have been detected in some cured meats. One or two of these nitrosamines appear frequently in fried bacon and have been found in frankfurters. Efforts of the USDA scientists are directed at finding substitutes for sodium nitrate and sodium nitrite, the traditional curing agents for these meats, or at devising other methods of applying the agents that will block nitrosamine formation.

Finding an alternate for sodium nitrite as a curing agent is not easy because of the peculiar combination of advantages nitrite provides. Not only does it give

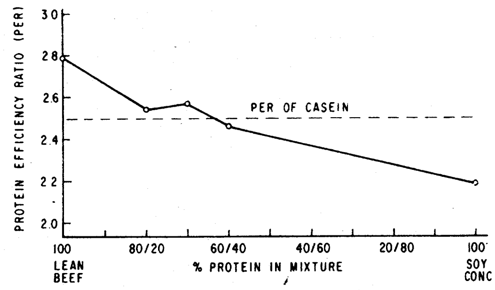


FIG. 1. *Protein efficiency ratios* (PER) *for protein mixtures of lean beef and a soy concentrate compared with casein at a* PER *of 2.5.*

desired color and flavor and serve as a fat antioxidant, but most importantly, it protects the meat against the growth of *Clostridium botulinum* and toxin production. Any substitute curing agent that does not also provide such protection may just replace a potential danger with an actual one.

Nitrosamines appear only in parts-per-billion quantities. The Center is one of five or six laboratories in the world equipped for nitrosamine analysis, which involves gas chromatography, followed by mass spectrometry for positive identification. The mechanism by which nitrosamines are formed is exceedingly complex and so far has eluded efforts to understand it well enough to bring it under complete control.

One hopeful finding of the research thus far is that sodium ascorbate or sodium erythorbate, used with sodium nitrite, greatly suppresses nitrosamine formation (19). While the actual effectiveness of this scheme is being checked out in commercial practice, consideration is also given to further reducing the level at which nitrite compounds are used as curing agents for meat.

Meat blends

Research at the Eastern Regional Research Center has been aimed at making the highly nutritious, but expensive, protein of meat more widely available. One approach has been to blend other less costly proteins with lean beef without appreciably lowering the meat's protein efficiency ratio (PER).

The animal proteins blended with beef have included whey, fish, and cattle-blood proteins, and the protein residues from the low-temperature rendering of beef fat (20,21). The vegetable proteins used were from soy and cottonseed. Hide collagen was also included in these experimental blends. In spite of its nutritional limitations, the latter protein is highly digestible, and its combination with other proteins tends to maintain the natural texture of meat in the blended products. Collagen also makes a distinct nutritional contribution when the other proteins present compensate for its amino acid deficiencies.

This work showed that pure beef protein (PER of 2.8, as compared with a standard of 2.5 for casein) can have as much as 30 per cent of certain of these other proteins and protein combinations blended with it before its PER falls below 2.5. In fact, Figure 1 shows that, in blends of pure beef and concentrated soy proteins, a PER of 2.5 or better was maintained until the proportion of soy present began to approach 40 per cent (22).

In another study, samples of lean beef and partially defatted beef fatty tissues, including collagen, were analyzed for their amino acids and PER. A good correlation was found between the two analyses, and equations were developed that will accurately predict the PER of meat products from their amino acid analyses without costly animal testing (23,24).

Other nutrition-related research

Along with these major nutrition-related projects currently being pursued at the Eastern Regional Research Center, a continuing concern for food safety and wholesomeness pervades the entire program. For example, when an "instantizing" step was introduced some years ago to make nonfat dry milk reconstitute faster, amino acid analyses were made on the concentrated milk and on the powder at *four* processing plants to make sure the nutritional qualities of the product were not affected (25).

When the Center's research introduced formaldehyde pellets for the sanitization of maple-tree tapholes, the safety of the practice was recognized. Nevertheless, as an added precaution, procedures for formaldehyde analysis of maple sirup were adopted (26). In ten years of use, no sample has been seized for formaldehyde contamination.

Tests for salmonella and other toxic microorganisms are constantly being devised and applied to make sure that the safety of foods, such as cheese (27) and processed meats (28), will not be compromised by experimental processing methods under development.

In addition to the research on lactose intolerance and nitrosamines, scientists at the Center have tracked down other health problems related to foods. One relates to a claim made a few years ago that the consumption of blighted potatoes might be involved in the crippling birth defects, spina bifida and anencephaly. University of Wisconsin scientists, working under a USDA research contract with marmosets and rhesus monkeys, have failed to confirm the claim (29).

Similar nutrition-related research is also in progress on other food crops at the Eastern Regional Research Center's sister laboratories in Peoria, Illinois; Berkeley, California; New Orleans; and Athens, Georgia. These other installations are also resource centers of significance to the health and well-being of our people.

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